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METHODOLOGY FOR JEDEC FILE REPAIR THROUGH COMPRESSION

FIELD TECHNIQUES

This is a continuation-in-part of Application No.  
09/916,453, filed July 27, 2001.

Field of the Invention

The present invention relates to a method and/or architecture for file integrity generally and, more particularly, to JEDEC file integrity and preservation of programming specifications.

Background of the Invention

Files generated in compliance with the Joint Electron Device Engineering Council (JEDEC) standard JESD3-C are used for programming field programmable logic devices. The JESD3-C standard defines a format for transferring fuse or cell states between a development system and a programmer. The files consist of (i) non-programming fields within a design specification portion, (ii)

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device programming fields, and (iii) a cyclic redundancy check (CRC) portion.

Programming a device starts with presenting parameters defining a program to the development system along with non-programming type information. The development system generates programming items from the parameters. The programming items are then stored in the programmable fields of the file. The non-programmable type information is stored in the non-programming fields of the file.

The JESD3-C standard has several practical limitations. One limitation is that the files cannot be used to reverse calculate the original parameters. A common practice is to dispose of the original device programming parameters once the file has been verified as correct and the programmed devices have gone into production. Consequently, the original intent of the program is lost with the discarding of the parameters. Another limitation is that a corrupted file cannot be repaired.

#### Summary of the Invention

The present invention concerns a method of generating a file suitable for programming a programmable logic device. The

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method generally comprises the steps of (A) generating a programming item from a plurality of parameters that define a program for the programmable logic device; (B) compressing the programming item to present a compressed item; (C) storing the programming item in a programming field of the file in response to generating; and (D) storing the compressed item in a non-programming field of the file in response to compressing.

The objects, features and advantages of the present invention include providing a method and/or architecture for enhanced JEDEC file generation that may (i) preserve the ability to fully recreate the original parameters from the file, (ii) detect a change in bit position/bit values, (iii) substantially reduce tracking through file validation, (iv) preserve input and output frequency parameters, (v) provide full backward compatibility to pre-existing and future JEDEC file readers, and/or (vi) provide for repair of a corrupted file.

#### Brief Description of the Drawings

These and other objects, features and advantages of the present invention will be apparent from the following detailed description and the appended claims and drawings in which:

FIG. 1 is a block diagram of a system implementing the present invention;

FIG. 2 is an exemplary file created by the present invention;

FIG. 3 is a flow diagram of a process for generating and using a modified JEDEC file;

FIG. 4 is a flow diagram of a process for generating a compressed item for inclusion in the modified JEDEC file;

FIG. 5 is an exemplary listing of data generated by a Huffman encoding;

FIG. 6 is an exemplary file incorporating the compressed item; and

FIG. 7 is a flow diagram of a process for repairing a corrupted file.

#### Detailed Description of the Preferred Embodiments

Referring to FIG. 1, a block diagram of a system 100 is shown in accordance with a preferred embodiment of the present invention. The system 100 may be configured to program a programmable logic device 102 based upon one or more input items 104. The system 100 generally comprises a circuit 106, a transfer

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medium 108, a circuit 110, and a circuit 112. Other embodiments of the system 100 may include only one of the circuit 110 or the circuit 112. The circuit 106 may be implemented as a development system. The circuit 110 may be implemented as a hardware programmer. The circuit 112 may be implemented as a generic file reader and/or parsing engine. The transmission medium 108 may connect the development system 106 to the hardware programmer 110 and/or the file reader/parsing engine 112 to transfer a file 114.

The development system 106 may be configured to generate the file 114 from the input items 104. The input items 104 may include one or more programming parameters 116. The programming parameters 116 may define a program for configuring the programmable logic device 102. The input items 104 may optionally include one or more information items 118. The information items 118 may be non-programmable data stored in the file 114 for reference purposes. The information items 118 generally do not affect programming of the programmable logic device 102.

The development system 106 may comprise a processor 120 and software 122 residing in a memory 124. The processor 120 may be configured to execute the software 122. The software 122 may instruct the processor 120 to generate the file 114 from the input

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items 104. The processor 120 may format the file 114 per the Joint Electron Device Engineering Council (JEDEC) standard JESD3-C, hereby incorporated by reference in its entirety. The JESD3-C standard is published by the Electronic Industries Association, Washington, D.C.

The hardware programmer 110 may be controlled by software 126 to program the programmable logic device 102. The programmable logic device 102 may be connected to the hardware programmer 110 through a socket 128 or similar device. The hardware programmer 110 may receive the file 114 from the development system 106 through the transfer medium 108. The hardware programmer 110 may then program or flash the programmable logic device 102 using the programming items stored within the file 114.

The transfer medium 108 may be configured to distribute the file 114 among the development system 106, the hardware programmer 110, and the file reader/parsing engine 112. The transfer medium 108 may be implemented as a serial communication link, a network, a removable medium such as a disk or tape, or the like. Other forms of the transfer medium 108 may be implemented to meet the design criteria of a particular application.

The file reader/parsing engine 112 may be configured to parse the file 114. The parsing may recover the programming parameters 116 and the information items 118 saved as part of the file 114. The recovered items may be useful in determining the original intent of the program defined by the programming parameters 116. The recovered items may also be useful in debugging and/or analyzing the program defined therein.

Referring to FIG. 2, a diagram of an example file 114 implementing the present invention is shown. The file 114 generally adheres to a specific protocol that instructs the hardware programmer 110 on three basic principles. A first section 130 may be a comment section that outlines device identification and other comments. The fields within the first section 130 may be non-programming. A second section 132 may contain programming fields that store addressing information about where to start placing bits. The event of programming generally begins at a first address location and proceeds in a linear fashion until either an end-of-file is reached or a new address is detected. The second section 132 may be passed through a simple cyclic redundancy check (CRC) process and compared against a CRC value stored in a final

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section 134. The comparison may verify the accuracy of the contents of the file 114.

One or more special comment lines 136 may be included in the first section 130 to store some or all of the programming parameters 116 and the information items 118. In general, the comment lines 136 may comprise one or more lines and/or fields bracketed by delimiters. Existing and future third-party hardware programmers 110, file readers/parsing engines 112, and other equipment that may read the file 114 may be compatible the comment lines 136 per the JESDC-3 standard because the comment lines 136 are within the first section 130.

A general format of a first comment line 136 may be given by, "# x Checksum: aaaaaaaaa". The field "x" may represent a starting delimiter (e.g., "<"). The field "aaaaaaaa" may be implemented as a non-programming field that may store an error detection item. In one embodiment, the error detection item may be a unique CRC checksum that may be independent from the JESD3-C standard CRC value. The unique CRC checksum may be used by the development systems 106, the hardware programmers 110, the file readers/parsing engines 112, and other equipment to verify the file 114.



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be defined within the comment lines 136 to meet the design criteria of a particular application.

The delimiters may be implemented as a character, a symbol, a number, or the like. The delimiters may distinguish the comment lines 136 to the development systems 106, the hardware programmers 110, the file readers/parsing engines 112, and other equipment capable of reading the file 114. In one embodiment, the presence of carriage returns and line feeds between the delimiters may be ignored.

In an example, the programmable logic device 102 may be a programmable multiple phase-lock loop (PLL) device. The following applications may be used for the various fields of the comment lines 136. The "aaaaaaaa" field may store the unique checksum value (e.g., "74F47101") for the file 114. The "bbbbbbbbbb" field may store the device part number (e.g., "NMN3344"). The following fields "ccccccccc" and "ddddddddd" may store frequencies at various interfaces of the programmable logic device 102. In particular, the third comment line 136 may store an external reference frequency. The fourth through last comment lines 136 may store output frequencies for the various PLLs.

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Generation of the unique CRC checksum may consist of a series of registers. Starting immediately after the unique CRC checksum field (e.g., the "aaaaaaaa" field) or starting from the second portion 132, the file 114 may be read as an input data stream into a first register sequentially and "clocked" through the series of registers in tandem. Feedback may be provided where values of some registers are feed back to some previous registers. The feedback may be dependent upon coefficients that define a polynomial. Presentation of the input data stream into the generation process may continue until the whole ASCII "binary" bit input data stream has been entered. Once the entire input data stream has been entered, taps from specific registers may be used to generate the unique CRC checksum value.

The accuracy of the generation process generally depends on the number of registers and the coefficients of the polynomial. In one embodiment, there may be 21 stage registers and a predetermined polynomial. The combination of 21 registers and the predetermined polynomial may achieve a detection accuracy to a resolution that may detect a presence of a bit swap(s). Bit swapping may include swapping of position and/or swapping of values. Other combinations of registers and coefficients may be

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implemented to meet the design criteria of a particular application.

The generation process may be implemented in hardware, firmware, software, micro code, or any combination of hardware, firmware, software and micro code. The following is an example of a unique CRC checksum generation process implemented as a software program having 21 registers and a polynomial having all initial coefficients set to zero. The input data stream may be represented by an array[s]. The example code may be:

```
void SONOS::calculateChecksum(int tempEnd, char array[], char
checksum[])
{
    unsigned short reg[21];
    unsigned short temp;

    int j = 20;

    for (int k = 0; k < 21; k++)
    {
        reg[k] = 0;
    }
```

**SECRET**

5

1.0

15

20

```
for (int j = 20; j > 0; j--)
```

{

```
reg[j] = reg[j-1];
```

}

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}

int tempCurrent = 0;

tempCurrent += sprintf (checksum + tempCurrent, "%4X%4X",  
reg[15], reg[10]);

5 checksum[tempCurrent] = '\\0';

}

Other unique CRC checksum generation processes may be implemented  
to meet the design criteria of a particular application.

Referring to FIG. 3, a flow diagram of a method of  
generating and using the file 114 is shown. The process may begin  
with reception of the programming parameters 116 and the  
information items 118 by the development system 106 (e.g., block  
138). The processor 120 may then generate the programming items  
from the programming parameters 116 (e.g., block 140). The  
processor 120 may store, in no particular order, (i) the  
programming items in the programmable fields, (ii) selected  
programming parameters 116 in the non-programming fields of the  
comment lines 136, (iii) the identification item in a non-  
programming field of the comment lines 136, and (iv) add the  
starting delimiter and the ending delimiter to the comment lines  
136 (e.g., block 142).

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Once the processor 120 has generated the second portion 132 of the file 114, the processor 120 may generate the unique CRC checksum and a compressed item (e.g., block 144). The compressed item may be used to repair the file 114 if corrupted, as described later. The unique CRC checksum and the compressed item may be stored in non-programmable fields of the comment lines 136 (e.g., block 146). Optionally, the completed file 114 may be stored within the development system 106 for later transmission (e.g., block 148).

To program a programmable logic device 102, the file 114 may be transferred from the development system 106 to the hardware programmer 110 (e.g., block 150). The hardware programmer 110 may then use the second portion 132 of the file 114 to flash the program into the programmable logic device 102 (e.g., block 152). Programming may then be repeated with additional programmable logic devices 102 using the same file 114.

To recover the saved programming parameters 116, identification items 118, the unique CRC checksum and/or the compressed item, the file 114 may be transferred to the file reader/parsing engine 112 (e.g., block 150). The file reader/parsing engine 112 may parse the file 114 using the

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delimiters to extract the comment line or lines 136 (e.g., block 154). The comment lines 136 may then be separated by the fields into the identification items 118, the programming parameters 116, the unique CRC checksum and the compressed item (e.g., block 156).

5           The file 114 may then be validated against the unique CRC checksum (e.g., block 158). If the file 114 passes the validation (e.g., the YES branch of decision block 160), then the extracted programming parameters 116 and identification items 118 may be presented for display (e.g., block 162). In situations where the file reader/parsing engine 112 also has a programming capability, then the validated second portion 132 of the file 114 may be used to program the programmable logic device (e.g., block 164). If the file 114 fails the validation (e.g., the NO branch of decision block 160), then a file repair process may be performed (e.g.,  
15       block 166).

          The file repair process may use the compressed item to create a new or backup copy of at least the programming items. The compressed item may also be used to create a new or backup copy of some or all of the information items and/or programming parameters.  
20       The compressed item may exclude the unique CRC checksum.

Referring to FIG. 4, a flow diagram of a process for generating the compressed item for inclusion in the file 114 is shown. The process may begin by reading a portion of the file 114 (e.g., block 168). The portion generally starts from the comment line 136 immediately following the unique CRC checksum or from the second portion 132 to the end of the file 114.

The portion of the file 114 may be read as an input data stream into a compression process. The compression process may be implemented a Huffman encoding process. The Huffman encoding process may provide an effective compression for the entropy presented by the mean or average format type of the JEDEC file specification. The Huffman encoding may provide an overall process that may be deterministic by nature and noiseless in a default state. Other compression methodologies may be implemented to meet the design criteria of a particular application.

The Huffman encoding generally involves a dictionary for encoding/decoding. The dictionary for the Huffman encoding and Huffman decoding may be referred to as a Huffman tree or binary tree. The Huffman encoding generally creates the Huffman tree as part of the process. Since the Huffman tree may be required for

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decoding, the Huffman tree is commonly incorporated in the resulting compressed item.

The development system 106 may execute the Huffman encoding process to generate the compressed item (e.g., block 170).

5 To help minimized a size of the compressed item, the development system 106 may generate the Huffman tree (e.g., block 172) independently of the Huffman encoding process. As a result, a need to incorporate the Huffman tree into the compressed item may be eliminated. The following is an example of a Huffman encoding process implemented as a software program. The example code may be:

// Header file of Huffman encoder : Imported from "The Data  
// Compression Book, 2nd Edition" by Mark Nelson & Jean-loup Gailly  
// This information regarding implementing the process specifics  
15 // is subject to copyright © for the public domain Huffman encoding  
// section only.

class huffman

{

20 public:

huffman();

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virtual ~huffman();

public:

char \*CompressionName;

5 char \*Usage;

int input\_stream;

int output\_stream;

unsigned long \*counts;

NODE \*nodes;

CODE \*codes;

char \*printOut;

void count\_bytes( char \*input, unsigned long \*long\_counts );

15 void scale\_counts( unsigned long \*long\_counts, NODE \*nodes );

int build\_tree( NODE \*nodes );

void convert\_tree\_to\_code( NODE \*nodes,

CODE \*codes,

unsigned int code\_so\_far,

20 int bits,

int node );

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```
void output_counts( char *output, NODE *nodes );  
void input_counts( char *input, NODE *nodes );  
void print_model( NODE *nodes, CODE *codes );  
void compress_data( char *input, char *output, CODE *codes );  
5 char *expand_data( char *input, char *output, NODE *nodes,  
                    int root_node );  
void print_char( int c );  
  
void CompressFile( char *input, char *output, int argc, char  
                  *argv );  
char *ExpandFile( char *input, char *output, int argc, char  
                  *argv, NODE *nodes );  
  
void int2Bin( char* buffer, unsigned int code, int bits );  
15 void OutputBits( char *bit_file, unsigned long code,  
                  int count );  
  
int InputBit( char *bit_file, int index );  
  
};
```

```
20 /*Function definition of build Huffman binary tree */  
  
int huffman::build_tree( NODE *nodes )
```

0000000000

```
int next_free;
```

5

```
int min_1;
```

```
int min_2;
```

```
nodes[ 513 ].count = 0xffff;
```

```
for ( next_free = END OF STREAM + 1 ; ; next_free++ ) {
```

```
min_1 = 513;
```

```
min_2 = 513;
```

```
for ( i = 0 ; i < next_free ; i++ )
```

```
if ( nodes[ i ].count != 0 ) {
```

```
if ( nodes[i].count < nodes[min_1].count ) {
```

```
min_2 = min_1;
```

```
min_l = i;
```

```
}else if (nodes[i].count < nodes[min_2].count)
```

```
min_2 = i;
```

}

```
if ( min 2 == 513 )
```

```
break;
```

```
nodes[ next_free ].count = nodes[ min_1 ].count
```

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```

+ nodes[ min_2 ].count;

nodes[ min_1 ].saved_count = nodes[ min_1 ].count;
nodes[ min_1 ].count = 0;
nodes[ min_2 ].saved_count = nodes[ min_2 ].count;
5 nodes[ min_2 ].count = 0;

nodes[ next_free ].child_0 = min_1;
nodes[ next_free ].child_1 = min_2;
}

next_free--;
nodes[ next_free ].saved_count = nodes[ next_free ].count;
return( next_free );
}
```

/\* Function definition of CompressFile

15 \* The function changes to "malloc" to memory instead of the  
\* default file I/O routine specified in the original process.  
\*/

```
void huffman::CompressFile(char *input, char *output, int argc,
char *argv )
```

```
20 {
    unsigned long *counts;
```





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```
while ( ( c = input[input_stream++] ) != '\0' )
```

```
{
```

```
    sprintf(buffer, "");
```

```
    int2Bin( buffer, (unsigned long) codes[ c ].code,
```

```
            codes[ c ].code_bits );
```

```
    strcat(output, buffer);
```

```
}
```

```
    sprintf(buffer, "");
```

```
    int2Bin( buffer, (unsigned long) codes[ END_OF_STREAM ].code,
```

```
            codes[ END_OF_STREAM ].code_bits );
```

```
    strcat(output, buffer);
```

```
}
```

```
15  /* Function definition of convert_tree_to_code
```

```
    */
```

```
void huffman::convert_tree_to_code( NODE *nodes, CODE *codes,  
unsigned int code_so_far, int bits, int node )
```

```
{
```

```
20    if ( node <= END_OF_STREAM ) {
```

```
        codes[ node ].code = code_so_far;
```



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encoding may allow every six bits of binary data to be represented as a single symbol. The Base 64 encoding may result in additional compression (e.g., 1/6th) representation of the compressed item as stored in the file 114 due to the  $2^6$  symbol size. The Base 64 encoding may result in a high base or a highest base for a printable character symbols set for an ASCII file.

The symbols may then be mapped into an ASCII character representation (e.g., block 175) that may be viewed and printed inside the file 114. Symbol base representation may be handled directly through fixed tables inside the development system 106. The fixed tables may help minimize a size overhead requirement of the resulting compressed item.

The compressed item in the ASCII character format may then be stored in the first section 130 of the file 114 (e.g., block 176). The following is an example of a Base 64 encoding process implemented as a software program. The example code may be:

```
/* Header file for base 64 compression
```

```
Take the raw Huffman output and convert the contents to base 64  
mapping such that all information can now be viewable, and/or  
printable.
```

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\*/

class base64

{

public:

5 char \*Dec2Bin(unsigned short dec, int bits);

void deCompress(char \*input, char \*output);

base64();

virtual ~base64();

10 void bin2Dec(char \*array);

void compress64(char \*input, char \*output);

int base64ConvertedValue;

char base64Array[65];

15 };

// base64 class Constructor : The ASCII table construction happens

// here

base64::base64()

20 {

// ASCII table construction

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```
// 64 ASCII character were chosen and base64Array holds all  
// characters
```

```
int j = 62;
```

```
int i = 0;
```

5

```
for (int k = 1; k < 65; k++)
```

```
{
```

```
    i += sprintf(base64Array + i, "%c", j);
```

```
    j++;
```

```
}
```

```
base64Array[64] = '\\0';
```

```
}
```

```
/* Base 64 compress function definition
```

15     \* Take the raw Huffman output and convert the contents to base 64

```
    * mapping such that all information can now be viewable, and/or
```

```
    * printable.
```

```
*/
```

```
void base64::compress64(char *input, char *output)
```

20     {

```
        long inputLength = strlen(input);
```

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double remainder;

int chop;

double fl;

int intRmdr;

5 int belowDecimal;

if (inputLength % 6)

{

remainder = (double)((double)inputLength / 6);

chop = (int)remainder;

fl = (double)(remainder - chop);

intRmdr = (int)(fl \* 6);

belowDecimal = 6 - intRmdr;

15

for (int k=inputLength; k<inputLength+belowDecimal; k++)

input[k] = '0';

output[inputLength/6] = '\\0';

20

for (int i = 0; i < inputLength/6; i++)

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```

    {
        bin2Dec(input);
        output[i] = base64Array[base64ConvertedValue];
        input = input + 6;
5      }
    }
    else
    {
        output[inputLength/6] = '\\0';
        for (int i = 0; i < inputLength/6; i++)
        {
            bin2Dec(input);
            output[i] = base64Array[base64ConvertedValue];
            input = input + 6;
15      }
    }
}

```

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Referring to FIG. 5, an exemplary listing of data 178 generated by a Huffman encoding is shown. The data 178 may be shown in FIG. 5 as an ASCII binary representation for ease of

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presentation. The data 178 in a pure binary form may have a smaller size (e.g., 1/8th) what is shown in FIG. 5.

Referring to FIG. 6, an exemplary file 114A incorporating the compressed item is shown. The file 114A may comprise the first (non-programming) section 130, the second (programming) section 132 and the final (CRC) section 134. Multiple comment lines 136A may be provided for within the first section 130.

The compressed item may be stored in one or more comment lines 136A within the first section 130. In one embodiment, the compressed item may be positioned before the unique CRC checksum. Positioning the compressed item before the unique CRC checksum may alleviate a potential deadlock situation by keeping the processing elements mutually exclusive. Other position arrangements of the compressed item within the first section 130 may be implemented to meet the design criteria of a particular application. The compressed item shown in FIG. 6 may be generated from the Huffman encoded data shown in FIG. 5.

A general format of a first comment line 136A may be given by, "Compression ID vv". The field "vv" may represent a starting delimiter (e.g., "<<"). A second comment line 136A may be given by, "eee...eee". The field "eee...eee" may be implemented as

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a non-programming field that stores the first several characters of the compressed item. Additional comment lines 136A may also provide additional fields "eee...eee" as necessary to store additional characters of the compressed item. Another comment line 5 136A may be given by, "uu". The field "uu" may represent an ending delimiter (e.g., ">>"). Additional fields and delimiters may be defined within the comment lines 136A to meet the design criteria of a particular application.

The delimiters within the comment lines 136A may be implemented as characters, symbols, numbers, or the like. The delimiters may distinguish the comment lines 136A to the development systems 106, the hardware programmers 110, the file readers/parsing engines 112, and other equipment capable of reading the file 114A. In one embodiment, the presence of carriage returns and line feeds between the delimiters may be ignored. 15

As with the file 114, the file 114A may be transferred among the development system 106, the hardware programmer 110 and/or the file reader/parsing engine 112 via the transfer medium 108. Since the compressed item may be stored in the first section 20 130 of the file 114A, conventional hardware programmers 110 may accept and use the file 114A for programming the programmable logic

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devices 102. The conventional hardware programmers 110 may treat the compressed item as a non-programming comment.

The file reader/parsing engine 112 and/or the development system 106 may be configured to parse, separate, decode and decompress the compressed item from the file 114A as necessary. In general, the file reader/parsing engine 112 and the development system 106 may parse the compressed item while parsing the file 114A (e.g., block 154 of FIG. 3). The decoding and decompression of the compressed item may be performed as part of the file repair process (e.g., block 166 of FIG. 3).

Referring to FIG. 7, a flow diagram of a process for repairing a file 114A that has been corrupted is shown. Prior to the file repair 166, the parsing of the file 114A may be performed using the delimiters to extract the comment lines 136A (e.g., block 154). The comment lines 136A may then be separated or extracted by the fields into the identification items 118, the programming parameters 116, the unique CRC checksum and the compressed item (e.g., block 156). After the validation of the file 114A (e.g., block 158) has failed (e.g., the NO branch of decision block 160), the file repair (e.g., 166) may be initiated.

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The file repair 166 may begin by mapping the ASCII character representation of the compressed item back into the symbol representation (e.g., block 180). The mapping of the ASCII characters to the symbols may be performed through fixed tables.

5 The symbol representation of the compressed item may then be decoded back into the binary representation (e.g., block 182).

The decoding may be implemented as a Base 64 decoding. The Base 64 decoding may convert the symbols into binary data. For example, the Base 64 decoding may convert each symbol into six bits of binary data. The following is an example of a Base 64 decoding process implemented as a software program. The example code may be:

/\* Base 64 decompress function definition

\* Take the JEDEC file input and convert the contents from base 64

15 \* mapping.

\*/

```
void base64::decompress(char *input, char *output)
{
    char temp[50000];
    20    int length = strlen(input);
```

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reader/parsing engine 112 may generate the Huffman tree (e.g., block 186) prior to the actual decompression. The following is an example of a Huffman decoding process implemented as a software program. The example code may be:

5 /\*  
\* Expanding compressed data. Imported from "The Data Compression  
\* Book, 2nd Edition" by Mark Nelson & Jean-loup Gailly. This  
\* information regarding implementing the process specifics is  
\* subject to copyright © for the public domain Huffman decoding  
\* section only. As each new symbol is decoded, the tree is  
\* traversed, starting at the root node, reading a bit in, and  
\* taking either the child\_0 or child\_1 path. Eventually, the  
\* tree winds down to a leaf node, and the corresponding symbol is  
\* output. If the symbol is the END\_OF\_STREAM symbol, it doesn't  
15 \* get written out, and instead the whole process terminates.  
\*/  
  
char \*huffman::expand\_data( char \*input, char \*output, NODE \*nodes,  
int root\_node )  
{  
20 int node;  
int index = 0;

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```
char tempOut[2];
```

```
char tempOutput[50000];
```

```
sprintf(tempOutput, "");
```

```
5  for ( ; ; ) {  
    node = root_node;  
    do  
    {  
        if (input[index] == '1')  
            node = nodes[ node ].child_1;  
        else  
            node = nodes[ node ].child_0;  
        index++;  
    } while ( (node > END_OF_STREAM) );  
  
15  
    if ( node == END_OF_STREAM )  
        break;  
    sprintf(tempOut, "%c", node);  
    tempOut[1] = '\\0';  
  
20    strcat(tempOutput, tempOut);  
  
    }
```



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extracted from the compressed item (e.g., block 194). If the programming items and the backup copy of the programming items are the same (e.g., the YES branch of decision block 196), then the validation failures of the programming items (e.g., block 158) and the backup copy (e.g., block 188) may be due to a corrupted unique CRC checksum.

A new unique CRC checksum may then be generated based upon the file 114A (e.g., block 198). The new unique CRC checksum may then replace the corrupted unique CRC checksum (e.g., block 200) to repair the file 114A. After the replacement has completed then the file repair 166 process may be complete. Processing may continue with the steps of presenting the programming parameters and information items (e.g., block 162) and programming of the programmable logic device (e.g., block 164 of FIG. 3).

If the comparison fails (e.g., the NO branch of decision block 196), then an extent of the corruption may be uncertain. Therefore, a repair of the file 114A may not be possible. The user may be alerted with an error message (e.g., block 202) and processing ended.

The function performed by the flow diagrams of FIGs. 3, 4 and 7 may be implemented using a conventional general purpose

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digital computer programmed according to the teachings of the present specification, as will be apparent to those skilled in the relevant art(s). Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will also be apparent to those skilled in the relevant art(s).

The present invention may also be implemented by the preparation of ASICs, FPGAs, or by interconnecting an appropriate network of conventional component circuits, as is described herein, modifications of which will be readily apparent to those skilled in the art(s).

The present invention thus may also include a computer product which may be a storage medium including instructions (or computer program) which can be used to program a computer to perform a process in accordance with the present invention. The storage medium can include, but is not limited to, any type of disk including floppy disk, optical disk, CD-ROM, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, Flash memory, magnetic or optical cards, or any type of media suitable for storing electronic instructions.

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While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention.

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